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Measuring the effectiveness of learning with serious games in corporate training

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Abstract

This paper discusses metrics for the effectiveness of learning of serious games in corporate training. Existing evaluation models are examined in order to verify their applicability to modern organizations in the knowledge economy. Designing metrics for learning requires taking into account different stakeholders, such as the employees, the employers and the management for the financial side. Game builders can also benefit from metrics that relate known game features, such as immersion, to learning effectiveness. Such metrics would allow an early assessment of the suitability of a game for training, thereby reducing the consequences of a wrong design and the development costs.

Keywords: serious games; evaluation; metrics; corporate training; knowledge management; game features.

1. Introduction

Serious games have been attracting the interests of corporations as a potential way to improve training effectiveness. For example, to reduce the time it takes for a learner to become productive and effective on the field, thus reducing Time To Competence (TTC) which is a strategic goal of organizations [1]. This need will be ever growing in the current situation of a knowledge economy, where knowledge is rapidly evolving.

Nevertheless, due to the costs of serious games and the costs of reorganizing existing training programs, the adoption of the former will not happen unless there is a clear benefit for corporations in doing so. Providing evidence of the advantage in using serious games requires tackling the following two general issues:

- Evaluate existing models of learning effectiveness to see whether they apply to the corporate situation

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- Define who the stakeholders are and what metrics would suit their needs

Regarding the first point, there is the need to assess not only what the employee has learnt, but also how this knowledge is applied. Moreover, the focus should not be only on the single individual and on knowledge assets, but on how individuals as a team can contribute to the transfer of knowledge assets.

Regarding the second point, we believe that metrics need to be used by different stakeholders and therefore be different, such as Return of Investment for financial departments and Job Relevance for employees. Stakeholders do not only belong to the corporate training environment, since also game builders would benefit from metrics that can guide in developing a game. In this process, early feedback on the quality of the game is crucial in order to reduce the costs of the final product. There is an extensive literature on features that make a "good" game. The research challenge is to investigate how those features relate to the effectiveness of learning.

This paper is organized as follows: in section 2 we present existing evaluation models for corporate training effectiveness, and briefly discuss their advantages and disadvantages. Based on the findings in this section, in section 3 we discuss important factors in defining metrics for learning effectiveness. The stakeholders and the metrics they require are discussed in section 4, while some relationships of game features and the importance of such relationships for the design of metrics are presented in section 5. Finally, we provide some conclusions in section 6.

2. Existing approaches to evaluate learning and knowledge transfer for corporate training

In this section several existing theories and models in relation to (corporate) learning and measurements of corporate learning are presented. The current attention for the use of serious games finds its roots in the shift towards knowledge as key factor in the modern business environment. As such the rise of knowledge management will be discussed as well as several theories concerning the facilitation of knowledge management.

2.1. Nonaka's SECI knowledge model

The SECI (Socialization, Externalization, Combination, Internalization) model from Nonaka and Takeuchi [2] has been one of the most important models to have come from this increase of attention for knowledge management. This model presents the flow between the processes of explicit and tacit knowledge. Explicit knowledge can be expressed in formal and systematic language and for instance be shared in the form of data, but tacit knowledge is much harder to articulate [3]. Tacit knowledge lives in action, it comes alive in and through doing things, in participation with each other in the world. Therefore, tacit knowledge can be distributed among people as a shared understanding that emerges from working together [4].

The SECI process consists of four modes of knowledge conversion (see also Figure 1[†]):

- Socialization: The process of converting new tacit knowledge through shared experiences
- Externalization: The process of articulating tacit knowledge into explicit knowledge
- Combination: The process of converting explicit knowledge into more complex and systematic sets of explicit knowledge
- Internalization: The process of embodying explicit knowledge into tacit knowledge

In this paper we use this model to refer to how knowledge evolves in corporations. As discussed in the previous section, social interactions are a good indicator for measuring the knowledge flow, and should be part of the metrics aimed at measuring the process of tacit knowledge transfer.

[†] Taken from http://editthis.info/jsarmi/Nonaka_SECI_Model

2.2. Kirkpartick's framework

The framework that Donald Kirkpatrick has developed has been used over more than 40 years as a basic model for the evaluation of corporate training efforts and interventions. The model presents evaluation methods and connects these to four different levels: reaction, learning, behavior and results [5] (see Table 1).

Table 1 Kirkpatrick structure

Evaluation Level	**Evaluation**		
	Type (what is measured)	Description and characteristics	Examples of tools and methods
1	Reaction	Reaction evaluation is how the delegates felt about the training or learning experience.	'Happy sheets', feedback forms. Verbal reaction, post-training surveys or questionnaires.
2	Learning	Learning evaluation is the measurement of the increase in knowledge - before and after.	Typically assessments or tests before and after the training. Interview or observation can also be used.
3	Behavior	Behavior evaluation is the extent of applied learning back on the job - implementation.	Observation and interview over time are required to assess change, relevance of change, and sustainability of change.
4	Results	Results evaluation is the effect on the business or environment by the trainee.	Measures are already in place via normal management systems and reporting - the challenge is to relate to the trainee.

Although this framework for evaluating corporate training has been around for forty years, a recent benchmarking study found that the majority of evaluation efforts (94%) are stuck in level 1 [6]. Furthermore, the approach of Kirkpatrick to training evaluation was aimed at the method of classroom instruction which was predominant in those days. When trying to develop metrics for evaluating serious games use and effectiveness in the modern corporate industry, a reassessment of the Kirkpatrick evaluation framework should be considered.

One important characteristic of learning in nowadays organizations and which is not captured by the Kirkpatrick's model, is the introduction of social media and social learning [6].

2.3. Return on Investment (ROI)

Established in the area of econometrics, the concept of calculating a Return on Investments (ROI) started in the 1970s and after a decade of refinement and application started to take more notion with its global recognition in the 1990s [7]. The ROI methodology uses six types of data with one consisting of the classic ROI formula for which this methodology is most used for:

$$ROI\ (\%) = (Total\ Program\ Benefits - Total\ Program\ Cost) / Total\ Program\ Cost * 100.$$

The ROI methodology consists of the phases and activities shown in [7] (see Table 2):

Table 2 Overview of ROI methodology

Phase	Activity	Data collection
Planning	Develop evaluation plans and baseline data	Inputs/Indicators
Data collection	Collect data during program	Reaction and Planned action
	Collect data after program	Learning
		Application and Implementation
		Business impact and Consequences
Data analysis	Isolate the effects of the program	ROI
	Convert Data to monetary Values	Intangible Benefits
	Calculate the ROI: -Capture costs of program -Identify Intangible Measures	
Reporting	Reach conclusions and generate report Communicate Information to Target Groups	

Although the ROI methodology is now established in various project measure tools, it has not become commonplace in measuring corporate training efforts. When applying ROI principles to the evaluation of corporate training efforts, in general there are two approaches [8]:

- Data is collected from large samples of companies and compared to the experiences of companies that do invest into training against companies that do not
- Case study method: Detailed data from a single company are collected to estimate the costs and returns from the training program of the company

3. Requirements for metrics to measure effectiveness of learning in corporate training

The shift towards knowledge economy in corporate training has very strong implications on the way the effectiveness of learning is understood. Based on the survey in the previous section we recognize two characteristics as most important:

- Effectiveness of learning is understood not in terms of direct learning outcome (what has been learnt), but in terms of how an individual **applies the acquired knowledge** and contributes to the company's strategic outcome.
- The knowledge asset per se is not that important; it is the **transfer of knowledge** between individuals which is the key process in the contemporary knowledge economy.

These two most important aspects have direct implications on the way effectiveness of learning in corporate setting should be measured, that is, the accent of measurement falls on the processes rather than the outcomes.

Tacit knowledge is strategically the most important type of knowledge [9] and the measurement of the effectiveness of learning in corporate training should take it into consideration. Tacit knowledge is work related, practical knowledge that is not explicitly expressed and therefore difficult to transfer by writing it down or verbalizing it [10].

Tacit knowledge is very difficult to measure as the people who have it are often not even aware of it. Again, the focus should not be on tacit knowledge as an asset, but on the processes of knowledge transfer related to it, namely the processes of externalization, combination, internalization and socialization, as described in the SECI model.

A good starting point in measuring the knowledge flow related to the effectiveness of learning in corporate training is measuring the levels of **social interactions**. The rationale behind is the observation that most

knowledge is constructed and emerges as a result of social interaction [9]. Moreover, it is through social interaction that tacit knowledge is externalized.

Related to the previous point, an important critique of the current competence development metrics is that they are exceedingly individualistic and fail to examine knowledge and capabilities on the collective level [9]. In that respect any future measurement should emphasize **inter-subjective factors** and social interaction instead of individual propensities [9].

Further important characteristic of measurements in the context of corporate training is their **predictive power** and the ability to give indications about the knowledge and competences that will be needed in the future [9]. Metrics should allow planning, reporting and improving [6].

To meet the metrics requirements, as described above, some fundamental shifts in the prevailing paradigms for measuring effectiveness of training and effectiveness of serious games are needed.

The measures for effectiveness of learning for serious games have to be designed from the position of 'measure in order to understand the field' rather than from the prevailing current departure point of 'measure in order to control'. Such shift will put an accent on measuring features describing dependencies and relations between the objects rather than features pertaining to the objects themselves. Understanding the processes and interdependencies related to effectiveness of corporate training can also ensure the predictive power of the metrics.

4. Requirements related to the needs of different stakeholders

Measuring serious game-based training within corporate environments is a complex issue that needs to be examined from more than one side. There is a shift towards measuring the impact of a particular learning strategy rather than just how much the employee learned [6]. The game has therefore to satisfy the requirements of different stakeholders:

- The Employee for the user experience as a trainee
- The Employer and Organization for the increased capacity to perform tasks
- The Management for the improved financial balance

These stakeholders provide input for the metrics that need to be applied to a game in a corporate training. Together with the explicit Educational Objective, they form the metrics criteria. This approach is based on the educational perspective for adult training, complemented with the organizational perspective, looking both at employer's and employee's gain, plus the management and financial sides. In the following we describe these metrics from top to down, i.e. from the most high-level and far from the game experience to the closest one.

4.1. Management-driven metrics

The Return on Investment is important feature when evaluating the investment in games used for training versus the improvement in company's employees. This data offers important information to game designing companies even though it is not easy to relate to the original game used in the training.

The financial effectiveness of employing a particular serious game-based training in a corporate context can be measured with the following performance indicators:

4.2. Employer-driven metrics

Employer relevant performance indicators in case of serious games based corporate training focus on on-the-job task efficiency, by looking at the capability of the trainee to perform job-related tasks after training (related to time and finance invested per trainee). Efficiency and effectiveness need to be redefined in accordance with what knowledge economy deems to be an efficient and effective employee performance.

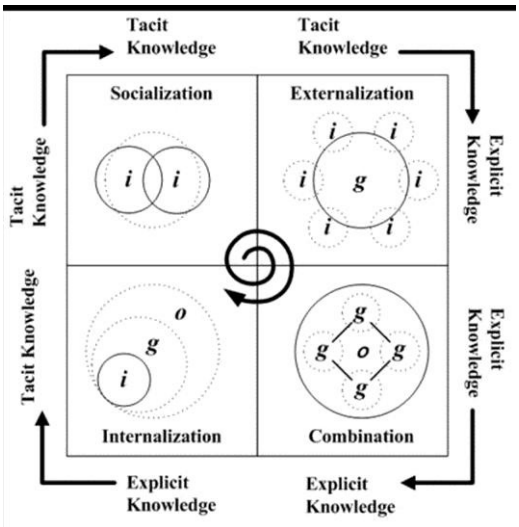

Figure 1 The SECI model

The concept of Return on Expectation represents the expectations the employer has from her employee in a post-training evaluation. Return on Expectation does:

- measure changes in behavior
- measure the success on the job (task accomplishment as quality in time)
- show the overall business impact of the training program
- measure the improvement in productivity

Each company adapts business indicators and productivity indicators to be measured in a post-training session. Another performance indicator relevant for employers but directed at evaluating the game itself more than the learning is the attendance of the game-based training, i.e. the number of individuals from field-related branches that access the same game-based training program. This shows the complexity of the program to cover as many skills and field-related problem-based tasks to be solved in reaching different objectives, specific for different branches of the same company.

4.3. Employee-driven metrics

From the employee's perspective the user experience is important. Here the user is both a trainee and an employee. Therefore, the elements to measure are:

- User's motivation to complete the training to be measured.
- Self-efficacy: the belief about one's own capabilities to produce designated levels of performance.
- Accessibility of the game given the difficulty level shown in the complexity of tasks within game-training.
- Job relevance of the skills to be used within game tasks, compared to the employee's job description. The number of skills employed as well as the correspondence between the skills employed in game solving and skills expected in the job description gives a measure of the appropriateness of the certain game-training for the field envisaged.

In order to solve tasks the trainees sometimes need to access resources. The use of prior theoretical input is something to be measured by the number of accessed resources during the game, which gives data on trainee's

self-confidence on the input he had already gained prior to in-game training, while collaboration or its lapse also influences trainee's motivation to perform.

4.4. Educational objectives

The extent to which the number of expected training objectives was met can be observed looking at changes in skills/ attitude. Performance indicators are:

- number of tasks solved
- number of resources accessed
- gains and losses within a certain time frame.

These are the basic elements to be measured inside the game for both cognitive, psycho-motorial and affective skills. Kraiger, Ford, and Salas [11] stated that learning can be measured by changes in affective, cognitive, or skill capabilities. Moreover, simulation game theories stressed out that affective, behavioral, and cognitive processes are all critical indicators of training effectiveness ([12]; [13]; [14]).

5. Relevant relationships of game features for metrics

As discussed in section 1, we need an understanding of the relationship between game mechanics and features contributing to the learning effectiveness of a game. Such understanding would allow measuring different design features at different stages of the game development that in turn can feed back the game design process. This eventually would reduce the high cost of games as this is one of the main reasons preventing their widespread use.

In this section we describe game features for which there are existing metrics and strong indications for relatedness to effectiveness for learning and knowledge transfer, both of importance in evaluating effectiveness for learning/training in corporate setting. The exact way in which the described features are related to effectiveness of learning and knowledge transfer is still to be determined through empirical studies. Even more important for measuring the effectiveness for learning will be the understanding of the interdependencies between the features we present and features related to pedagogical principles. Such understanding can further inform the metric design so that by measuring a particular learning outcome it is also possible to understand why it has been achieved.

To that end we identify two elements from literature:

- The features that are used to evaluate games
- How those features relate to each other

This results in a hierarchy of different features related by two relations: **prerequisite** and **composed-of**. The relation prerequisite means that if *A* is prerequisite of *B*, *B* cannot happen unless *A* has happened. Different authors have sometimes different views on what the same term indicates, and use the same terms in different contexts. In order therefore to harmonize these different views, the relation composed-of can also mean a generic *related-to*

We further present the hierarchy and the relationships together with the features they apply to (see Figure 2). We concentrate on some of the most researched ones, as a complete study of game features and their relations is out of the scope of this paper.

- *Effectiveness for learning*

The feature that is the focus of this paper is *effectiveness for learning.* It is also at the top of the hierarchy that we present. Reference [15] proposes an approach for measuring *effectiveness for learning* where effectiveness is seen as a collective measure of *usability*, *playability* and *learning outcomes.* Olsen follows an

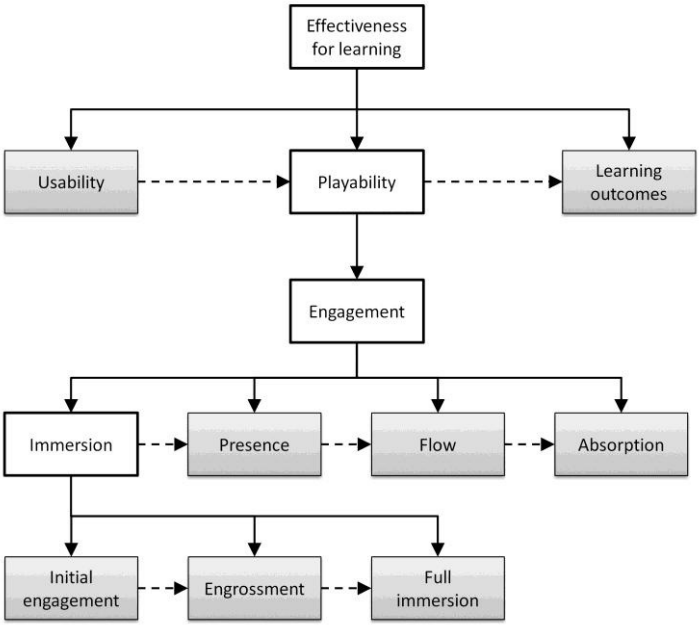

Figure 2 Hierarchy of game features and their relationships. Dashed lines mean prerequisite, continuous lines mean composed-of. Features in white boxes are measured through features they are composed by.

already established approach to test and measure usability of systems and adapts it for serious games for learning. In the staged approach described by [15], firstly general usability and playability are tested. In order to have any reliable measure of playability, some basic level of usability needs to be there. Furthermore, no learning outcomes can be achieved unless there is some level of playability present. The approach allows testing games for the baseline levels of usability and playability. This test can be performed early on and subsequent corrective actions can be taken before the game is fully developed, at which stage any change is much more costly and difficult to implement.

5.1. Playability

Playability has been defined by [16] as "entertainment without fear of present or future consequences; it is fun". There aren't well developed and used measurements for playability; it is measured by using the developed scales for *immersion, presence, flow* and *engagement* [15]. In the following we further specify how playability depends on the above mentioned features by adopting a more granular decomposition of engagement as found in literature. We also assume playability can be measured based on that.

5.2. Engagement

Reference [17] developed a game *engagement* questionnaire which measures the levels of psychological engagement when playing games. Engagement is seen as passing through several stages from low to high engagement. These stages are *immersion*, *presence*, *flow* and *absorption* where immersion indicates the lowest

levels of engagement and absorption is associated with the highest levels of immersion. The questionnaire has the potential to identify the different levels of engagement when playing a game.

5.3. Immersion

Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in and interacting with the continuous stream of stimuli of the environment. Immersion is mainly associated with Virtual Environments, but any strong identification with characters or experiences from a particular environment is a state of immersing in this environment [18].

According to the grounded theory of immersion developed by [19] there are 3 stages of immersion where each stage is characterized by a particular barrier that needs to be removed to get access to the stage. The first stage is *initial engagement* (different from the previously introduced engagement) and the first barrier is *accessibility*. The game has to be easily accessible at the beginning which is achieved by satisfying user preferences, getting the right usability levels by providing easy to learn controls, adequate feedback, etc. Another barrier is investment of time, effort and attention. The value of investment needs to be high. Once these two barriers are passed, the gamer enters into the stage of *engrossment*. This stage is characterized by emotional involvement. Features related to this stage are visuals, interesting tasks and interesting plot. As the game progresses the levels of investment increases, i.e. the time and effort spent are higher and the attention needed to perform the game is higher. And while in reality the gamer's investment of time and effort is higher, her perception of the actual values is lower. The final state of immersion is *full immersion*. The barriers for total immersion are empathy and atmosphere. To get totally immersed in the game the gamer needs to feel empathy with the characters she is playing, feel that she is the character from the game. It has been noticed that this particular state is related to the type of the game, that is first person games and role play games seem to provide an easier access to this state. Atmosphere is related to the game constructs, like graphics, plot, etc. The last stage of immersion engages the three levels of attention: visual, auditory and mental. The increased levels of attention are tightly related to game mechanics mechanisms and more concretely reward mechanisms. In the first stages of the game each investment has to be rewarded fast and adequately. At the later stages the reward is actually employing mechanisms that lead to higher levels of attention engagement.

5.4. Presence

Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another [18]. Presence is an important feature defining Virtual Environments and for which measures have been devised. We describe the measure for presence because many of the factors that appear to affect presence are also known to affect learning and performance [18]. This is a strong indicator that the degree of presence is associated to learning effectiveness of serious games and might therefore be important to enable it.

When measuring presence [18] take into account Sheridan's finding [20] of the subjectivity of presence as it is a mental manifestation that is not easily amenable to objective physiological definition and measurement. Thus presence is seen as function of individual differences and the characteristics of the environment and a presence measure should assess both.

5.5. Flow

Flow has been measured by [21], using the experience sampling method. The method measures different aspects of flow like skills and challenges, mood and motivation. As a different method [22] developed the Flow

Questionnaire which describes different flow experiences to which the respondents firstly indicate whether they had similar experiences and then they rate these experiences on 12 dimensions.

Reference [23] measured flow as it is experienced when playing computer games. The questionnaires measure the intrinsic interest for a game, the player's sense of curiosity about a game and her sense of control and immersion. A critique to these measurements is that they take into consideration just a few of the aspects that are normally associated to flow [17].

According to [21] the state of flow seems to enhance learning.

5.6. Absorption

Psychological *absorption* has been measured by the Tellegen Absorption Scale [24] and is a measure of one's tendency to experience alterations of consciousness. This is a state in which one's feelings, emotions and rational thought are not accessible in a normal state. Absorption is a state different from flow along the line of two main characteristics: motivation and affect. Negative affect, like anxiety and frustration, though experienced in game play, are not characteristics of the state of flow.

5.7. Discussion

As discussed in section 3, a paradigm shift in metrics design will be needed to meet the requirements for measuring the effectiveness of learning of serious games in corporate setting. To achieve a shift towards a focus on processes of knowledge transfer rather than the assets and outcomes of learning/training, and understanding why a particular measured outcome has been achieved, we take a first methodological step. First we need to understand what relationships exist between different features and how this knowledge can further be used in the metrics design. To this purpose we analyzed game features that have been reported to have influence on the effectiveness, from a new perspective, that of finding out in what way these features are interrelated. The two main relationships we identified are:

- the **composed-of** relationship tells that a particular measurement is composite, for example if we want to measure engagement we need to measure first immersion, presence, flow and absorption
- the **prerequisite** relation indicates the existence of threshold measures of a particular feature before another feature can become effective.

These two relationships influence therefore the design of metrics for effectiveness of learning in serious games.

6. Conclusions

This paper presents preliminary work on different points of view necessary to the design of metrics for effectiveness of learning with serious games in corporate training. We claim that three factors need to be looked at when designing such metrics:

- The current situation of modern organizations, where knowledge plays a key role. In particular, tacit knowledge and the collaborative and social interactions through which it is externalized and transferred. The focus of metrics should also therefore consider processes, not just 'objects' such as knowledge assets.
- The different stakeholders in corporate training, i.e. the management, the employers and the employee, besides the educational objectives that each corporation has.
- Relations between game features and how they impact learning, to avoid considering a game as a black box where learning might or might not happen (and if it happens it is not clear why it happened). Such an increased understanding can be fed back to the game designers, so that their efforts can be guided and errors avoided, with a decrease in costs.

For each of these factors we attempt at further specifying metrics and, in case of game features, how these metrics relate to each other.

As future work we plan to investigate further how game features impact learning, based on what we discussed in this paper. This includes how features influence learning and how they relate to each other in achieving a learning effect. Moreover, we want to investigate further metrics that look at knowledge transfer processes, with particular attention to tacit knowledge and social interactions.

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